All canines, including wolves, foxes, coyotes, and dogs have tough feet capable of withstanding the cold, although wolves are far superior compared to dogs in this aspect. Each of the wolf's toes is surrounded by stiff, bristly hairs to insulate them. Wolves also have special blood vessels that keep footpads just above the freezing point, preventing build-up of ice and snow. At night, wolves curl up with their tails around their noses and feet, retaining the warm air exhaled by the lungs to keep their feet warm, and foxes also do this. Foxes have footpads that are completely covered in fur. Foxes that are found further north tend to have furrier feet.

Although the natural environment has meant that natural selection helped to form the dog as we know it today, most modern breeds have been ‘created’ by humans due to artificial selection, where only those dogs expressing the desired characteristics are chosen for breeding. Artificial selection can be seen particularly in dogs more than any other species, where we have breeds as diverse as the Chihuahua and the Great Dane, with many other breeds in between, which have been bred either for their looks or for their characteristics that are useful for people. Some dogs have characteristics that would mean that in the wild they would be less likely to survive. However these genetic mutations persist because people like the novelty value and so have continued to breed from these animals. Examples of this include the breeds such as the dachshund, which has exceptionally short legs.

**A dachshund**

Other examples of abnormal genetic mutations that have created new breeds include the hairless dogs such as the Mexican Hairless and the Hairless Khala. As well as the lack of hair, many of these dogs have dental problems and lose many of their teeth in early adulthood. Obviously in the wild an animal that does not have the protection of hair, or the ability to chew food would be unlikely to survive long, but domestication and protection by humans means that dogs with these genetic mutations are able to survive and reproduce, passing on their genes to future generations.

## Genetic drift and gene flow

Dogs are not as sexually choosy as some species of animal, and therefore the differences between the sexes are not so marked. Also the domesticated dog does not usually live in conditions where it is able to choose its own breeding partner, with most breeding being done under controlled conditions. Within wild populations of dogs, inbreeding is generally avoided.

## Inbreeding versus outbreeding

It is generally accepted that inbreeding can increase the likelihood of recessive harmful alleles pairing up to result in offspring that express an inherited genetic condition, and under natural conditions many species go to great lengths to avoid inbreeding, and dogs are no exception. However artificial selection has meant that for most breeds of dog, inbreeding is very common.

To achieve desired genetic results, all successful breeders, today and in the past, use and have used the system of linebreeding and inbreeding. The breeder wishes to keep desired qualities and characteristics of a breed and eliminate undesirable traits.

**Linebreeding** is mating animals who are closely related to the same ancestor but are not closely related to each other through any other ancestors.

**Inbreeding** is a much closer cross between the mating pair than line breeding, for example breeding sons with mothers, or brothers to sisters. The purpose of both linebreeding and inbreeding is to narrow the pedigree to a few closely related lines of descent, to allow the breeder to have control over characteristics. Inbreeding reduces the genetic variability and aims to eliminate genes for undesirable recessive characteristics.

At the other end of the spectrum, outbreeding can lead to problems as well as inbreeding. **Outbreeding** is the crossing of two closely related, although separate species. If two animals breed that are genetically very different, then the resulting offspring may be incapable of reproducing themselves. A canid example is the wolf and jackal. They can interbreed and produce fertile hybrid offspring, which are sometimes known as huskals, and coyote and jackal hybrids have also been bred as pets. Dogs have been crossed with golden jackals, however, they cannot produce fertile offspring with yellow jackals as the golden jackals have only 74 chromosomes compared to 78 in the dog. The difference in chromosome number leads to problems in cell division and hence infertility.

Coydogs (male coyote/female dog) can also occur naturally, although the breeding cycles of dogs and coyotes are not synchronised and this makes interbreeding uncommon. It is believed the male coyote sperm count remains low or dormant for most of the year and is raised only for about 60 days in the spring in conjunction with the female coyotes once a year heat cycle. Coyote males usually stick with one female through the breeding season as well, even assisting in feeding and raising the puppies. For a coyote and a dog to mate, the choice of female coyotes would have to be so low that the male had not already paired up, then he would have to meet a female dog who happened to be in season within the same two month period that he was producing sperm. If hybrids are produced, because coyotes are solitary by nature, this trait may be carried across to the coyote-dog hybrids, resulting in unsociable behaviour.

**Coyote / Siberian husky cross**

Wolf-dog hybrids are quite sought after, and many of them are in existence, particularly in the USA. Crossbreeding between dogs and wolves in the wild does occur occasionally. Wolves are seasonal breeders and breeding in the wild is most likely to occur when a roaming feral dog and a lone wolf of opposite sex meet during the wolf's breeding season. With regards to keeping them as pets, there is much controversy surrounding the subject, as wolf-dog hybrids may express behavioural problems when kept as family pets.

## Genetic testing

There has been considerable research into the canine genome over recent years. The knowledge has led to the development of genetic tests to determine if dogs are affected.

In the case of a discovery of an exact mutation, the diagnosis is accurate. For genes with one letter changes there is a simple way determine the presence of mutations by using diagnostic enzymes (called restrictions enzymes) that recognise a string of letters representing the region around the mutation. The portion of the gene surrounding a mutation can be synthesised in the laboratory by a process called PCR (polymerase chain reaction). DNA samples can be obtained from any cells, and are usually taken by scraping the inside of the cheek.

Many tests are now available and are beginning to affect breeding programmes. The precise mutation leading to the PRA disease in Irish Setters is now known, and so the DNA from dogs can be analysed to classify the dogs as normal, affected or carriers. The test is highly accurate and a joint Animal Health Trust and Kennel Club testing scheme is now in operation, which means that all Irish Setters carrying the gene are banned from breeding and showing.

In addition to the genetic DNA tests that are available, other schemes aimed at reducing the incidence of genetic defects include the British Veterinary Association and Kennel Club scoring scheme for hip dysplasia. This has been in operation since 1984. It involves taking x-rays of the hips of dogs and then each hip is scored

according to its structure and development. The lower the score the less the degree of hip dysplasia is present. An average mean score is calculated for all breeds scored under the scheme and the advice for breeders is to use only breeding stock with scores well below the breed mean score. Potential buyers of puppies are advised to enquire about the hip scores of the dam and sire of the puppy they wish to purchase.

The BVA/KC/International Sheep Dog Society (ISDS) Eye Scheme offers breeders the possibility of eye testing to screen for inherited eye disease in certain breeds, such as those where specific hereditary eye conditions are known or suspected. By screening breeding stock for these diseases, breeders can use the information to eliminate or reduce the frequency of eye disease being passed on to puppies. The eye scheme currently relates to conditions involving the eye itself and not those involving the tear ducts, the eyelids or other surrounding structures. Therefore hereditary eye conditions of the lens, retina and other internal structures are listed, whilst eyelid conditions such as entropion and ectropion are not.